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THE DEVELOPMENT AND TESTING OF AN EXPERIMENTAL POLYSENSORY SELF-INSTRUCTIONAL SYSTEM DESIGNED TO HELP STUDENTS ACQUIRE BASIC ELECTRICAL OCCUPATIONAL COMPETENCIES. FINAL REPORT NO. 19.

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AN EXPERIMENTAL POLYSENSORY SELF-INSTRUCTIONAL SYSTEM DESIGNED TO ASSIST STUDENTS IN ACQUIRING AND APPLYING KNOWLEDGE OF THE NATURE, CONVERSION, AND TRANSMISSION OF ELECTRICAL ENERGY AND OF PRINCIPLES OF SIMPLE EELECTRICAL CIRCUITS WAS DEVELOPED AND TESTED FOR EFFECTIVENESS. RELATED LABORATORY EXERCISES WERE AN INTEGRAL PART OF THE SYSTEM WHICH CONSISTED OF A SERIES OF TAPE-SLIDE SEQUENCES PRESENTING INFORMATION IN A LINEAR PROGRAMED PATTERN AND A WORKBOOK IN WHICH THE STUDENTS WERE ASKED TO RESPOND TO A WIDE VARIETY OF QUESTIONS AND PROBLEMS. PARALLEL FORMS OF PRE-TEST AND POST-TEST CRITERION MEASURES DEVELOPED FOR THE STUDY DETERMINED THE KNOWLEDGE GAIN OF THE SAMPLE OF 30 BOYS AND GIRLS IN GRADES THREE THROUGH 12. THE TOTAL MEAN TIME REQUIRED TO COMPLETE THE THREE LESSONS IN THE SYSTEM WAS 3.3 HOURS. THE SYSTEM FUNCTIONED WITH RESPECT TO INDIVIDUAL STUDENT DIFFERENCES AND INDEPENDENTLY OF INSTRUCTOR ASSISTANCE A MAJOR PART OF THE TIME. ANALYSIS OF POST-TEST SCORES INDICATED THAT THE AVERAGE ACHIEVEMENT WAS 60.1 PERCENT OF POSSIBLE ACHIEVEMENT AND THAT VARIATIONS IN ACHIEVEMENT WERE ASSOCIATED WITH DIFFERENCES IN AGE. LOW, AVERAGE, AND HIGH ABILITY STUDENTS LEARNED EQUALLY WELL FROM THE SYSTEM. LISTS OF REFERENCES ARE INCLUDED. (HC)

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June 1968

U.S. DEPARTMENT OF
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Edwin K. Hill

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Washington State University, Department of Education, Pullman, Washington
State Coordinating Council for Occupational Education, Olympia, Washington

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SUMMARY

The specific objectives of this study were:

1. To develop an experimental polysensory self-instructional system enabling pupils to acquire and apply knowledge of the nature, conversion and transmission of electrical energy and of principles of simple circuits.
2. To measure the extent to which defined electrical occupational competencies are developed by use of the system.
3. To determine the various amounts of instructor assistance needed for acquisition of the defined competencies.
4. To measure how much instruction time is needed to acquire defined levels of competency by use of the system.
5. To obtain indications of ways in which the system can be improved.

The design of this study can best be characterized as a "Before-after Study with a Single Group." The gain in the dependent variable (Y), which in this case is basic electrical knowledge, from the pre-measure (Y_1) to the post-measure (Y_2) is taken as a measure of the effect of the independent variable (X), the system treatment.

This system was composed of a series of tape-slide sequences which presented information in a linear programmed pattern. Through the use of a workbook, students were asked to respond to a wide variety of questions and problems. Related laboratory exercises were an integral part of the system. Instruction and demonstrations were provided by the tape-slide mode by use of a student operated console developed for this study.

The sample used for this study was drawn from students in Anatone and Pullman, Washington. This sample consisted of 30 boys and girls ranging from third-graders to seniors in high school.

Analysis of the data collected by the study indicated that the experimental system did promote learning. Statistical evidence supported the concept that some types of instruction via polysensory self-instructional systems can be exceptionally effective. Basic electrical competencies were gained by students who differed greatly in age and ability.

Motivation associated with this mode of instruction seemed high, especially where theoretical information was applied to laboratory experiences. Students indicated that they could understand basic concepts with relative ease and that they enjoyed learning this way.

The self-instructional characteristics of the system were quite apparent. Very little instructor time was requested by individual students. After becoming familiar with this mode of instruction they requested less than 17 seconds of instructor assistance per pupil, per lesson.

Sufficient data has been collected by this study to guide valid revision of the system. Comments by juries of experts, school officials, and students involved in the instruction, in addition to statistical results on student performance, have identified weak points of the system. Concise records of student progress by means of this instruction are helpful in making decisions concerning sequencing, emphasis, and organization of system content.

It is recommended that the format of this study be revised and replicated on a larger scale. The author has refrained from generalizing with respect to either larger populations or other learning situations. Such generalizations may be appropriate, however, after system revision and replication.

Copies of the workbooks, tests and slide-tape sequences used for this study are available through ERIC, Vocational Education Center, Ohio State University, Columbus, Ohio. The prototype student operated console can be seen at Washington State University, Department of Education, Pullman, Washington.

Chapter I

INTRODUCTION AND RATIONALE

Greater numbers of students are seeking some kind of formal education beyond high school and this trend will continue. Vocational opportunities for these students are increasing in occupations that require more knowledge and technical skill and, therefore, more general and technical education. The United States Department of Labor estimates that by 1970 the number of professional and technical workers will increase by 41 per cent.

Many people are concerned about development of arrangements that will help vocational education keep pace with occupational change. For example, Ramo writes:

> . . . with the proper cooperation between experts in education, expert teachers, experts (in specific subject matter), and experts in engineering these automatic systems, we can evolve that high level of match between the human teacher and the machine that we seek in that improved high school.[1]

Porter suggests, as a partial solution, increasing the efficiency of the teaching process itself.[2] Modern educational technology can help provide adequate occupational education.

Strong advocates coordination of efforts. He suggests creation of a national advisory committee to coordinate programs of materials development, to define terminology used in curriculum work and to develop recommended formats.[3]

Facts underlying the above views highlight a need for development of better and more efficient technical instruction. Glaser suggests: "Let us try to apply effectively as much as we know; it might be enough to make a difference."[4]

Statement of the Problem

The purpose of this study is to develop and test the effectiveness of a polysensory, self-instructional system designed to help high school students acquire selected basic electrical occupational competencies.

The specific objectives of this study are:

1. To develop the experimental polysensory self-instructional system enabling pupils to acquire and apply a knowledge

of the nature, conversion and transmission of electrical energy and of principles of simple circuits.
2. To measure the extent to which defined electrical occupational competencies are developed by use of this system.
3. To determine the various amounts of instructor assistance needed for acquisition of the defined competencies.
4. To measure how much instruction time is needed to acquire defined levels of competence by use of the system.
5. To obtain indications of ways the system can be improved.

Rationale and Need

The above information about results obtained from systems such as this one should help meet the following educational needs?

1. Enable instructors to provide quality instruction for larger numbers of pupils.
2. Provide a wider variety of subject matter alternatives.
3. Enlarge students' opportunities to do independent work.

Research and theory of learning, reinforcement, individual pacing, self-evaluation, and multisensory contact support the logic of this experiment. Studies have shown that multisensory approaches facilitate some types of learning.[5] This investigation will throw further light on the hypothesis that a combination of these instructional elements will facilitate learning.

Auditory instruction, visual displays, and manipulative laboratory exercises will be used to involve the students' senses of hearing, sight, and touch in the learning process.

Definition of Terms

Systems means a combination of instructional materials and processes that jointly contribute to specified outcomes.

Self-instructional means learning experiences designed to function relatively independently of the instructor. A prime consideration is maximum allowance for individual differences among students.

Polysensory means student use of a varied, yet coordinated, combination of educational media, which involves as many senses as is feasible in the learning process.

Reinforcement, as defined by Skinner, conotes a strengthening of the student's capability, readiness and disposition to behave in certain ways.

Jury denotes a competent group of people assembled to verify content and establish guide lines, values, or acceptable levels of achievement.

Linear Programming refers to the organization of instruction into a series of small, sequential segments presented in a definite order. Often referred to as Skinnerian programming, it provides a single path for the learner with all students reading and responding to the same material.

Criterion tests used by this study are the standard of achievement by which performance of the learner will be measured. These are tests of knowledge of basic electricity and performance capabilities which have been derived from the established behavioral objectives.

Use of adjunct programs refers to separate media, not necessarily a part of the system, which may be utilized by learners for remedial purposes.

References, Chapter I

[1] Simon Ramo, "A New Technique of Education," Engineering and Science Monthly, XXI (October, 1957), 17-22.

[2] Douglas Porter, "A Critical Review of a Portion of the Literature on Teaching Devices," Harvard Educational Review, XXVII (Spring, 1957), 126-147.

[3] Merle E. Strong, "An Investigation of Trade and Industrial Education Curriculum Material Development and Curriculum Laboratories in the U.S.," Unpublished Ph.D. dissertation, Ohio State University, 1958. Dissertation Abstracts, LIX, 1601.

[4] Robert Glaser, "Christmas Past, Present, and Future," Contemporary Psychology, V (June, 1960), 24-28.

[5] Stanton P. Thalberg, "An Experimental Investigation of the Relative Efficiency of the Auditory and Visual Modes of Presentation of Verbal Material," Unpublished Ph.D. dissertation, State University of Iowa, 1964, Dissertation Abstracts, LXIV, 7949; Donald P. Ely (ed.), "Alphabetical Listing of Terminology," Audio-Visual Communication Review, XI (January, 1963), 44.

Chapter II

REVIEW OF RELATED LITERATURE

The value of utilizing educational technology has been recognized for many years. In 1926 Pressey argued for the release of the teacher from many of the routine tasks so that "she can be a real professional teacher, not a clerical worker."[1] He advocated an "industrial revolution in education." Skinner writing later during the initial development of programmed instruction, also voiced the need for use of this new technology as a means of releasing the teacher to do "real teaching."[2]

However, thoughtful people also express concern about the effectiveness of new technology in education and reservations about the extent and limits of its use.

For example, Gaudin states:

> Audio-visual devices can and should, from time to time, be used in the classroom, but their proper place is in the language laboratory. Many teachers who believe in the oral approach justly feel that they could get better results if they were given smaller classes and more hours per class rather than more machines.[3]

Measures of student achievement associated with the use of teaching machines are questioned by Votaw and Danforth. They suggest that "the resulting scores represent in part an ability in mechanical-transfer as well as an ability in the subject matter."[4] Gates feels that: "In general, the elaborate mechanical devices should be regarded as a last resort to be used when other methods have failed . . . ."[5] Speer suggests that "instruments . . . are not a substitute for a good teacher."[6]

Pressey, however, notes that:

> The teaching machine is no Frankenstein monster, threatening all present texts, materials, equipment, and even many teachers! Rather, automation should be the greatest help the schools have ever had.[7]

Lumsdaine agrees that teaching machines "could modify profoundly many of our basic conceptions of instructional methods and of the role of the teaching aid and audio-visual material in the education process."[8]

He views the teacher as becoming the "manager" of an entire instructional system, a planner, coordinator, and consultant--in short, a director of learning.

Erickson more specifically defines the "roles" of audio-visual materials in education. He notes that effective use of A.V. media will:

> Provide the teacher with means of extending the horizon of experience.
>
> Help the teacher provide meaningful sources of information.
>
> Provide the teacher with interest-compelling spring-boards into a wide variety of learning activities.
>
> Assist the teacher in overcoming physical difficulties of present subject matter.
>
> Enlarge pupil purpose when communicative materials are produced jointly by pupils and teachers.
>
> Provide the teacher with a kit of tools to carry out diagnostic, research, and remedial work demanded by up-to-date instructional purposes.[9]

Desirable qualities of new educational technology are cited by Briggs, who states:

> For all students, bright or dull, the machines are infinitely patient and accurate. They never scold the student, and they never employ sarcasm.[10]

Other writers indicate that use of the "machine" in education enlarges opportunities for students to surmount difficulties and limitations. It exhibits equal patience for the slow as well as the fast learner. There is no discrimination between rich and poor; and no distinction is made with regard to race, color, or creed.

Blyth states:

> Fortunately, the mechanization of the media of communication has not mechanized the mind of all those who have something to communicate. No more will the mechanization of methods of presenting instructional materials mechanize the materials to be presented.
>
> We do not yet know what part of our educational program should be presented in this manner. But it is clear that thoroughly tested programs will make it possible to come closer to realizing the democratic idea of equal education opportunity for all.[11]

Carr suggests that a self-instructional device might best be thought of as an automatic tutor which presents the learner with a series of problems, each of which requires some appropriate action on his part. Since it is not necessary that the instructor be familiar with all details covered by the material, a vastly enlarged and enriched learning area is available for the capable student.[12]

Automatic tutoring by intrinsic programming is seen by Crowder as an individually used method of teaching, which represents an automation of the classical process of individual tutoring. He defines intrinsic programming as the technique of using the students' choice of an answer to a multiple-choice question to determine the next material to which he will be exposed.[13] This technique can be implemented with a number of specific devices. The simplest device, called a "TutorText," is a specifically prepared book while a more sophisticated device for handling intrinsically programmed materials is a microfilm, the "Tutor."

Programmed instruction creates other desirable conditions for education. Bennett states that, "Programmed learning methods may well relieve group leaders of some of their present instructional functions and free them for more of the complex and subtle aspects of group guidance."[14]

New Technology in Mass Education

There is evidence of the application of new technology in mass education. Educational television has been accepted as a means of presenting material to large groups of learners simultaneously. Enders conducted a study with sixth grade science students to determine academic achievement resulting from supplementary instruction by television. He found more improvement in the group instructed by television.[15]

Wittich and Schuller feel that modern mass education must provide an expanded curriculum for increasing numbers of students with a wide range of individual differences in ability.[16] Counts declares that: "If one of the values of American education is to remain the achievement of individual excellence, some method has to be found to permit more attention to the individual student."[17]

The Systems Approach

Finn suggests an extreme view that a next step is used of combinations of mass and individual instruction technology to achieve a condition of "total educational automation."[18]

Meierhenry also suggests that possibly the ideal learning situation will emerge from a blending of various teaching media. As a result of his research pertaining to the introduction and use of audio-visual materials, he recommends that development of a multiple-media system should be pursued with awareness to the relationship of media to people, to other media, and to specific learning objectives.[19]

Dr Suess reasons that:

> The problem then becomes one of maximizing learning by the judicious selection of methods appropriate to situations or students, thus, research to find a superior method is almost certainly doomed to failure. A more realistic approach would be to study the most efficient use of the many methods available to the teacher.[20]

Guetzhow, Kelly, and McKeachie advise that "the complexity of the teaching-learning process is such that attempts to establish the relative merit of a 'general method of teaching' are likely to prove inconclusive."[21] A need for more specific investigations in various subject-matter fields is indicated. Much research indicates that such an investigation should emphasize a broader base for course development with awareness of technical advances in communication.

Such an approach was viewed as an improvement in training processes by Curl who carefully combined 2 x 2 slide sequences with tape-recorded narration to teach equipment operation skills to foreign students having English language handicaps. He found that this combination of media, utilized in a self-instructional type program was an effective means of teaching perceptual-motor skills. The substitution of captions for the verbal cues, when properly integrated with the visual, also gave satisfactory results.[22]

Another study by Curl utilized the self-instructional technique with an 8-mm loop film and a programmed 2 x 2 slide sequence. The students approached this learning situation in a completely unstructured atmosphere, working with the equipment in any sequence, testing themselves, and allotting as much time to each situation as they felt they needed. Encouraging results were obtained.[23]

Suggestions for Design and Selection of Systems

Concepts of reinforcements are considered to be an important aspect of this new technology. Organization of material into small, sequential steps is suggested by most writers. Many also indicated that additional reinforcement is gained by inclusion of laboratory experiences in the learning process, thereby involving additional senses.

The use of cumulative sequence media in industry to improve performance, particularly to reduce errors and increase production by assembly line workers, was evaluated by Klass,[24] Reshovsky,[25] and others.

A 2 x 2 slide sequence of the steps in the operation was presented in phase with the actual performance by the worker. Synchronized tape-recorded instructions and background music were also used.

The cumulative sequence approach, combined with the self-instructional technique, was used experimentally by others, including Haleff[26] at Hunters College, Mars [27] at Syracuse University, Reeves and Torkelson,[28] and Torkelson[29] at Pennsylvania State University.

The importance of practice is emphasized by Guthrie who advocates the utilization of various stimuli which indicate to the student that certain responses are appropriate. For example, he suggests that behavior must be evoked before it can be strengthened.[30] In a later work he states that "a student does not know what was in a lecture or book, he learns only what a lecture or book caused him to do."[31]

Suggestions made by Blyth are helpful for the design, selection and us of self-instructional systems. They are:

1. The system should be packaged in small units.
2. It is desirable to achieve low duplication cost. (Film is recommended.)
3. Storage should be designed to provide ready access to the materials and to protect them from damage.
4. Teaching devices should be easy to operate.
5. Automatic scoring features should be incorporated as an aid to the student and a program evaluation device for the teacher.
6. Use of audio in addition to visual presentation is recommended.[32]

A guide to programming a specific subject is outlined by Gilbert. He emphasizes the responsibility of the programmer to analyze the material closely, never letting the device dictate the program. With this in mind, he warns against the temptation to develop teaching programs to fit the device.[33]

The process of porgramming instructional material, whether for textbooks or some other presentation device has been discussed by numerous experimenters. Pressey cited programmed instruction as a system in which "the law of recency operates to establish the correct answer in the mind of the learner . . . ."[34]

Skinner states that "the task ahead for the development of this technology calls for ingenious application of much of what we already know."[35] He defined the "Skinner Device" as an organized sequence of material in small steps in which successive problems are dependent upon earlier materials.[36] This raises the frequency of reinforcement to a maximum and reduces the possibility of the adverse consequences of being wrong.

Holland states that:

> Principles evolved from laboratory study of behavior have provided the possibility for the behavioral engineering of teaching. This new technology is thoroughly grounded in some of the better established facts of behavioral control. The future of education is bright if persons who prepare teaching machine programs appreciate this and appropriately educate themselves in the special, but truly not esoteric discipline.[37]

Porter claims that teaching machines actually tend to improve study habits. There are some indications of transfer to other areas of instruction.[38] Further, he recommends that:

> The role of teaching devices should be a major one because of the potential pay-off through application of technology to the educational process. Teaching devices are no "Pie in the Sky" to cure the ills of traditional education. We are only in the initial stage of developing a technology in instruction, and much experimentation remains to be done.[39]

Porter categorizes three essential features which distinguish the self-instructional device, or teaching machine, from the teaching aid. He notes that these devices:

1. Provide a sequence of problems designed to take the learner from a low to a high level of proficiency in given subject matter.
2. Requires some action on the part of the learner at every stage of the program.
3. Provide immediate confirmation or knowledge of results about the correctness of the learner's response.[40]

These criteria are of value when, as mentioned by Perry and Whitlock, almost all classroom paraphernalia can be considered teaching aids and devices.[41]

A number of studies indicate the efficiency of programmed instruction devices for reinforcement of human learning. Among these are studies by Woodworth and Schlosberg[42] in 1954 and Munn[43] in 1954. Hull[44] concluded that reinforcement is most effective when administered as quickly as possible after a response has been made. Laboratory work providing simultaneous practice by the learner or practice immediately after a demonstration was advocated by Klass,[45] Lefkowith,[46] and VanderMeer[47] as an effective method of reinforcement.

A somewhat different view is presented by Amsel who states that:

> It is not always desirable to minimize errors in education and training. It is argued also that the use of partial or continuous reinforcement schedules should be decided by the nature of the activity that the training is to promote, partial schedules being mainly suitable for building persistence into a relatively unchanging behavioral pattern.[48]

Amsel feels that a judicious and flexible use of cues and prompts in programmed instruction is a necessity. Meyer points to certain techniques of presenting material which incorporate the use of prompts.[49] Lumsdaine, in a discussion concerning design of self-instructional devices, also covers the topic of cueing. Questions raised are related to cue-strength and factors to be considered in decisions about which relative cue-strengths should be changed. He emphasizes the use of prompts or cueing devices to control error tendencies, and thus keep steps between frames of a program.[50]

The development of a program in small sequential steps is recommended by Keislar.[51] To reach all students, both the bright and the dull, there should be small steps in the presentation and a variety of multiple choice items.

Evans, Glaser, and Homme experimentally investigated the properties of verbal learning sequences or "programs" without employing a "hardware" teaching machine. They concluded that "learning sequences consisting of smaller steps are associated with immediate test performance, better retention, and fewer response errors in the course of learning."[52] They also observed that, in general, subjects performing purposefully designed learning sequences made higher achievement scores and exhibited less variability in performance than did subjects receiving conventional textbook presentation of the same material.

In teaching-machine research, some question has arisen as to which mode of response, multiple choice or constructed (write-in short answers) promotes more effective learning. Fry suggests that when recall is a criterion for learning, construct methods are best. Multiple choice items appear more effective if recognition is the criterion.[53]

Various modes of operation were used with manually simulated teaching machines in experimental training sessions conducted for junior college students by Coulson and Silberman. Results indicated that simulated teaching machines lead to significant learning by the subjects. The multiple-choice response mode took less time than construction-response. Also, smaller item steps require more training time but yielded higher scores than large item steps on the construction-response criterion subtest.[54]

Other studies indicate results likely to be obtained by varying the length and number of demonstration-attention periods and the length and number of practice opportunities. For example, Maccoby and Shefield analyzed a film demonstration learning situation. They concluded that practice should follow demonstration segments which constitute natural units of a task, particularly in the case of lengthy sequential tasks. Practice is the most effective when it involves the serial integration of the whole task.[55]

Research Related to the Use of Various Types of Media

If attention were focused on the "hardware" that presents instruction to the learner, a great many types could be discussed. Such machines have been tested and evaluated by studies conducted in a wide range of subjects to evaluate the efficiency of such instruction. Some of these devices have been developed from the ideas of practicing teachers and other experts employed in the field of education. Their values are appraised by Berger,[56] Morley,[57] Gustafson,[58] Olander,[59] and Torreyson.[60]

Use of other machines, designed by psychologists to utilize principles of learning are evaluated by Dallenback,[61] Smith and Tate,[62] and Pressey.[63] Rothkopf comments that:

> We must have better understanding of the fundamental nature of learning processes if we, as psychologists, are to make useful contributions to the technology of automated instruction.[64]

A general review of the stimulus type devices indicates that they present the learner with information about how to make a given response. They do not provide a setting for the practice of responses under specific and controlled circumstances. It seems that stimulus devices provide learning content without any assurance that a learning process will be carried out. Response devices, on the other hand, do give the learner the opportunity to practice responses. Stimulus devices and response devices considered separately appear to be truncated representations of teaching-learning situations. Combined use of these devices more nearly reproduces the characteristics of teaching which are required for efficient learning. Representative studies in this area were done by the Naval Training Devices Center,[65] Bortalozzo,[66] Gibson and others,[67] Hoban and Van Ormer,[68] Kinder,[69] McKown and Roberts,[70] and Whittich and Schuller.[71]

Much research has compared the effectiveness of various media for teaching mechanical skills, but the major emphasis is placed on training problems within the armed forces and/or industry. A classic study published by VanderMeer in 1943 reports results obtained by varied utilization practices in teaching lathe operations by the use of demonstration films. These results show that the use of films definitely reduces training time and enables learners to acquire more factual information about machine operation.[72] These cited advantages inspired others to attempt to teach perceptual-motor skills by the use of motion picture film and slides.

Roshal emphasizes the advantage of presenting the motions involved over presenting a series of static photographs when particular motions are important to the procedure. In his study on learning to tie knots by film, he found that portrayal of the demonstration from the viewpoint of the learner created a more effective film.[73]

The increased amount of individual instruction and guidance inherent in use of training films was noted by Kimble and Wulff as a factor in achieving superior learning.[74]

An attempt to improve training films was made by Hoehn and Lumsdaine by developing and testing various versions of loop films.[75] Some features of the 16-mm endless loop film, such as: cartridge loading, automatic start and stop, and controlled selection of portions of program to be viewed, have been refined and integrated into the operation of the 8-mm commercially produced systems of today. In another study the advantage, limitations, and special techniques dealing with the use of 8-mm loop film are summarized by Gerlach and Vergis.[76]

Other military studies include VanderMeer and Cogswell's investigation of film use to teach army trainees to operate a 16-mm motion-picture projector. The success of this experiment verified the value of film presentation as a means of teaching certain complex skills and inducing favorable attitudes toward performance of tasks.[77]

Jaspen explored the effect of a number of film variables in learning to assemble the breach block of a 40-mm antiaircraft gun. Ninety-eight per cent of the learners mastered this skill by use of the experimental training film. The success of this experiment was attributed to such factors as slow rate of development, forewarning of possible difficulties, enforcement by repetition of assembly demonstration, and opportunity for coordinated practice activity.[78]

Further suggestions on the development of training methods are offered by Lefkowith who reports efforts to train naval personnel. He concludes that there is an important interaction between the teaching methods and the testing situation. Since the success of training for a skill is measured by the acquired competence of the learner in performing that skill in a realistic situation, Lefkowith advocates that training should occur in a realistic situation.[79]

Johnson[80] and Freedman[81] studied the use of linear programmed texts. These texts were found quite satisfactory when clearly illustrated and carefully designed to elicit and reinforce student responses. They demonstrated advantages such as easy distribution, portability, and low quantity production cost.

A study by Glaser, Homme, and Evans indicated that even the best standard textbooks fail to utilize certain basic learning principles. Conventional textbooks' presentation does not ensure that the appropriate behavior will be evoked or, if evoked, that it will be adequately strengthened.[82]

Another work by Homme and Glaser outlines a basic format for the programmed text. It recommends that items be intered on one page and that answers be located on the following page, to facilitate immediate reinforcement.[83]

A similar study by Householder compared the effectiveness of an 80 frame linear program, a 60 page scramble booklet, and a standard textbook in teaching a unit on screw thread terminology and thread standards. While no statistical differences in achievement or retention were noted, a definite advantage of the programmed methods was reduction of teacher presentation time. However, the programmed procedure required more student study time.[84]

Self-scoring or immediate evaluation of responses is a vital aspect of programmed instruction. A device which allows students to evaluate their responses to test questions immediately creates a number of possibilities for the improvement of instruction. As far back as 1929, Curtis and Woods conducted studies which varified the superior results occurring when students grade their own papers.[85]

Peterson[86] made five comparisons between student performance evoked by reading instructions with and without the self-checking features. All comparisons showed statistically valid differences in favor of the self-checking procedure. On the average, the groups using that procedure gained from 2.4 to 3 times as much information as those who used only questions as a guide.

A pilot study of use of teaching machines in engineering education was conducted by Mayhew and Johnson. They reported substantial potential.[87]

The use of machines for both drill and testing in educational psychology yielded satisfactory results as reported by Little. He endorsed them as having a practical use in classrooms. "They are convenient for students, time and labor saving for teachers, and make possible instruction techniques not otherwise practicable," he stated.[88]

Articles by Peterson[89] in 1930 and 1931, Pressey[90] in 1932, Jensen[91] in 1949, and Pressey[92] in 1950 describe particular punchboard devices designed to facilitate the self-scoring technique. The use of punchboards in chemistry and citizenship classes at Syracuse University in 1946-1947 was analyzed by Angell and Troyer. They classified this device as a means "to help the student to increase ability in self-evaluation, to identify his own strengths and weaknesses in such a way that he may direct subsequent learning efforts more intelligently."[93]

Other techniques have been employed in an attempt to achieve self-scoring in tests. Peterson[94] and Pressey[95] describe the use of chemically treated paper which gives a color change when a mark is made in the right place.

A similar study by Hofer compared self-instructional materials and demonstrations in the teaching of manipulation operations in industrial arts. The superiority of the self-instructional method was supported.[96]

A study by Barlow at Erlham College (one of the first two colleges to undertake major research projects in automated instruction on a widely interdepartmental basis) explored procedures for improving the effectiveness of the teacher. This was done by using mechanical and electrical aids for guided self-instruction, programmed individual and group course work, and study of interrelations of the various kinds of teaching procedures in order to determine the best use of each.[97]

Lichtblau worked with 2 by 2 slides to teach industrial arts skills to junior high school students. He advocates concise and brief presentation, omitting explanations of why a certain procedure should be followed unless the explanation is connected in some way to the learning of the skill.[98]

Satisfactory results were obtained by Ferster and Sapon who taught German by programmed instruction. They reported that:

> The subject had no instructor and was given no formal statements of grammatical principles; yet, the material succeeded in teaching inductively such conceptualizations as gender, verb transitivity, morphology and syntax of the German case system, and sentence word order.[99]

Research of the psychology of reading has produced numerous devices which have been used successfully, some of which are described by Barbe,[100] Carter,[101] Dearborn and Anderson,[102] Dearborn, Anderson and Brewster,[103] and Perry and Whitlock.[104]

Moderate success was achieved by the use of an apparatus for studying and teaching visual discrimination automatically with pre-school children. Hively reports that this "device has exciting possibilities as a means of teaching and testing the very young, the handicapped, and the mentally deficient."[105]

New Technology for the Teaching of Electricity

This investigator has located relatively few studies dealing specifically with the application of technology to the teaching of electricity. Of those reviewed, several investigated the feasibility of self-instructional materials for direction of laboratory activities which typically require large amounts of teacher assistance, but none used a total self-instructional system approach for this instruction.

Ruehl compared the effectiveness of auto-instructional aid which gave students immediate knowledge of results for 120 electrical problems with the more common teacher-graded technique. Performance on a posttest administered after nine weeks of instruction revealed significantly superior results obtained by use of the auto-instructional device as compared with the teacher-graded technique.[106]

Bergman investigated self-instructional methods for teaching electricity by comparing the effectiveness of teaching machine program, a programmed textbook, and a standard textbook. Equality between groups was established from results of a pre-test measurement. Results of a combined mid-term and final examination revealed no significant difference between scores relating to the various treatment methods.[107] Lease made a similar study comparing results obtained from use of linear programming and standard textbooks for teaching electronics. He found no significant difference in learning or retention of factual knowledge after six weeks exposure to the two treatments.[108]

In another study college students enrolled in physical science courses were taught a unit on magnetic properties with instruction presented by lecture, lecture-demonstration, lecture-student experiment, and lecture-programmed learning methods. As reported by Ricker, all methods were equally effective in terms of pretest to posttest gain and retention at 141 days.[109]

More decisive results were reported by Johnston who compared teacher demonstration and shop activities as means of teaching electricity. It was found that students receiving demonstrations acquired significantly more information, required significantly less instructor time, and as a result, learned at a lower cost per student. His conclusion was that "consideration should be given to the inclusion of more demonstrations of principles and applications in the teaching of electricity."[110]

Summary

In reviewing the literature, many reports were found which contributed to the rationale of this study. Most significant are those of Porter[111] and Ferster and Sapon[112] which demonstrated that automatic teaching can result in more than simple rote learning. Weimer feels that today, automatic teaching devices can be build which with relatively small amounts of supervision would function satisfactorily for many areas of instruction ranging from kindergarten to college level.[113]

Search for effective combinations of instructional devices and procedures is wide spread. The "systems approach" seems to offer many advantages. Pask sees substantial potentials for the systems concept. He states that "the fact and the philosophy of this border country is a new, and to my mind, an exciting field."[114]

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Chapter III

DESIGN AND PROCEDURES

Design

This study can best be characterized as a "Before-after Study with a Single Group." This design is described in detail by Barnes.[7] It emphasizes use of "before" measurements which do not contribute to the learning of the student. To accomplish this, parallel pre and posttest forms were used and verification of the student responses on the pretest were withheld.

The gain in the dependent variable (Y), which in this case is basic electrical knowledge, over the premeasure (Y_1) to the postmeasure (Y_2) is taken as a measure of the effect of the independent variable (X), the system treatment. This, in effect, establishes each student as his own control.

Influence other than the experimental treatment was controlled as much as possible during the course of the experiment. Consideration was given to factors which might affect the student responses at the time of the "after" measurement.

Limitations

As in most experiments conducted in the school, it was difficult to control all factors which affected the observed results. This experiment was conducted just before the end of the school year, and normal interuptions inherent in school routine were experienced.

It was also recognized that a more accurate measurement of mental abilities could have been obtained if each student had been given the same form of mental measurement instrument. This did not prove feasible, however; and, in an attempt to obtain a consistent measurement, a conversion table was used to arrive at the reported results.[8]

The criterion tests developed for this study were new and were not validated against other measures. The researcher used the jury method to design measuring devices.

The scope of instruction tested by this study is limited to a few concepts and a small sample of students. Further testing of this method of instruction is needed before broad conclusions can be reached.

System Development

The development of an experimental instructional system is one element of this study. This development involved two separate steps: (1) planning and (2) component development.

Planning

The purpose of this system is to introduce students to fundamental concepts of basic electricity and their application to everyday life. Planning followed these steps:

1. Objectives were established which considered the needs of society, the opportunities desired for youth, and appropriate subject-matter content. These objectives and a list of references consulted for subject matter content are presented in Appendix A.
2. Observable or "Behavioral Objectives" were designed to reflect elements of learning situations. Attention was focused on a statement by Dr. Paul Whitmore, as quoted in Mager's book, Preparing Instructional Objectives:

   > The statement of objectives of a training program must denote measurable attributes observable in the graduate of the program, or otherwise it is impossible to determine whether or not the program is meeting the objectives.[9]

3. Learning experiences designed to evoke desired student behaviors were determined, described, analyzed, and sequenced. Particular attention was given to Farr's comments:

   > The area of electricity can be a vital portion of the school program by teaching the related theories and principles in terms of everyday experiences of the student.[10]

   Many authors begin electrical instruction with a description of atomic structure, charged particles, and other complex concepts which are totally unfamiliar to most students. This system attempts to acquaint the student with electricity as a form of energy observed in everyday life and presents ways electrical energy is transmitted and used. Elementary electrical circuits are constructed and their function is described.
4. An evaluation of media and instructional techniques with regard to their capabilities to elicit desired behavioral responses was conducted. Findings of related reserach were utilized in this evaluation. A valuable guide to

the relationship between various instructional media and selected learning objectives has been developed by Allen and is included in Table I.[11] The instructional media selected as a part of this system include:

35-mm slide sequences
Synchronized audio tapes
Laboratory apparatus
Printed visuals, drawing, charts, etc.
Self-testing and feedback devices

TABLE I

INSTRUCTIONAL MEDIA STIMULUS RELATIONSHIPS TO LEARNING OBJECTIVES[a]

Instructional Media	Learning Objectives					
	Factual Information	Visual Identifications	Principles, Concepts, and Rules	Procedures	Performing Skilled Perceptual-Motor Acts	Developing Desirable Attitudes, Opinions and Motivations
Still Pictures	Med	HIGH	Med	Med	Low	Low
Motion Pictures	Med	HIGH	HIGH	HIGH	Med	Med
Television	Med	Med	HIGH	Med	Low	Med
3-D Objects	Low	HIGH	Low	Low	Low	Low
Audio Recordings	Med	Low	Low	Med	Low	Med
Programed Instruction	Med	Med	Med	HIGH	Low	Med
Demonstration	Low	Med	Low	HIGH	Med	Med
Printed Testbooks	Med	Low	Med	Med	Low	Med
Oral Presentation	Med	Low	Med	Med	Low	Med

[a] William H. Allen, "Media Stimulus and Types of Learning," Audiovisual Instruction, XII (January, 1967), 27-31.

Component Development

This instructional system includes a series of tape-slide sequences. Information is presented in a linear programmed pattern by taped commentary supported by the visuals. The student is asked to respond frequently as he progresses. The responses consist of writing answers to questions, filling in blank spaces in incompleted sentences, solving mathematical problems or correctly finishing partially completed sketches in a workbook. Immediate verification of each correct response is provided by the system. The student is instructed to cross out all incorrect responses and make corrections.

Related laboratory exercises are also conducted with instruction and demonstrations provided by the tape-slide mode. This experimental system is implemented by use of an Automated Projection Console. (See Fig. 1.) Prime components of this console are the Audion tape recorder and the 35-mm Carousel slide projector. (See Fig. 2.) The Audion has the capability of playing back prerecorded tapes housed in easy loading plastic cartridges. Each cartridge has a capacity for 20 minutes of recorded commentary. Control signals in the form of a high frequency tone, recorded on the tape, are used to operate the Carousel projector. This provides automatic synchronization of the two media. Sensor tape is used to stop the Audion when a student response is requested. The student reactivates the system after completion of each response. The tape may be stopped by the student at any time. These features contribute to the self-pacing characteristics of the equipment.

Incorporated in the Automated Projection Console is a pull-out work shelf, a power panel, and storage space for tape cartridges, slide trays, and laboratory experience apparatus. The laboratory apparatus consists of a self-contained circuit board and quick-connecting conductors of various lengths. (See Fig. 3.)

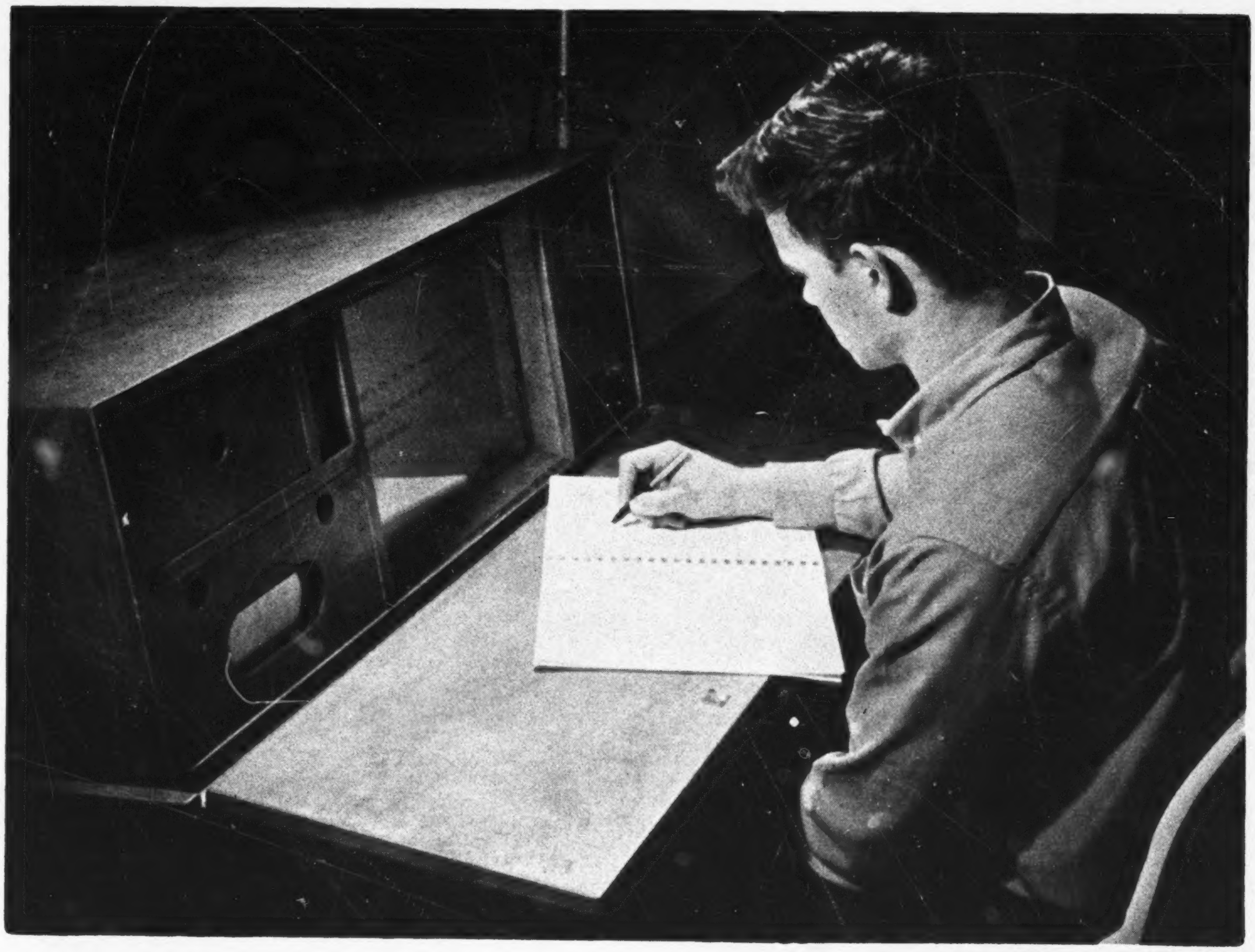

Fig. 1.--The Automated Projection Console

Tape-slide Sequence Development

The development of the tape-slide sequences followed the pattern recommended by Kemp.[12]

1. First a descriptive synopsis, or treatment, of the content of each lesson was developed. These treatments for Lesson I and Lesson II are included in Appendix B.
2. From these treatments a "story board" for each lesson was prepared. These consisted of 5 x 8 file cards bearing sketches of the visuals involved in the presentation, and narration notes. These cards were displayed on a bulletin board which facilitated the examination and organization of the entire sequence.
3. When continuity had been established on the "story board," a script for each lesson was written. This provided definite directions for the picture taking, and art work. Such scripts provide a picture-by-picture listing with accompanying narration and/or captions. They also give directions for the placement of the camera with respect to the subject. Narrations were written in tentative form at this point. Scripts for the introductory lesson on Equipment Operation and for Lesson I and II are presented in Appendix C.
4. Next, photographs were taken in accord with script directions. Much of the photography work involved reproduction of artwork and typed information. A copy stand was used to achieve stability. A Honeywell Pentax "Spotmatic" camera, with a Takumar close-up lense and Professional Kodachrome II (KPA-135) film was used.
5. For editing, all slides were arranged to follow the script and loaded into trays. A light box which displayed 144 slides simultaneously was utilized for this purpose.
6. At this point the narration was refined and checked to correspond with the slides. Cues needed for the recording session were provided. These final drafts of narrations with cues are reproduced in Appendix D.
7. After this refined narration was rehersed with use of the slides it was recorded on the master tape.
8. This final tape was copied onto the special lubricated tape used in the Audion cartridge. Metallic sensing strips were applied to the tape at the appropriate points for response stops. The tape was then loaded into the plastic cartridge and programmed with high frequency tones which control the slide presentation. This completed the construction of the tape-slide media.

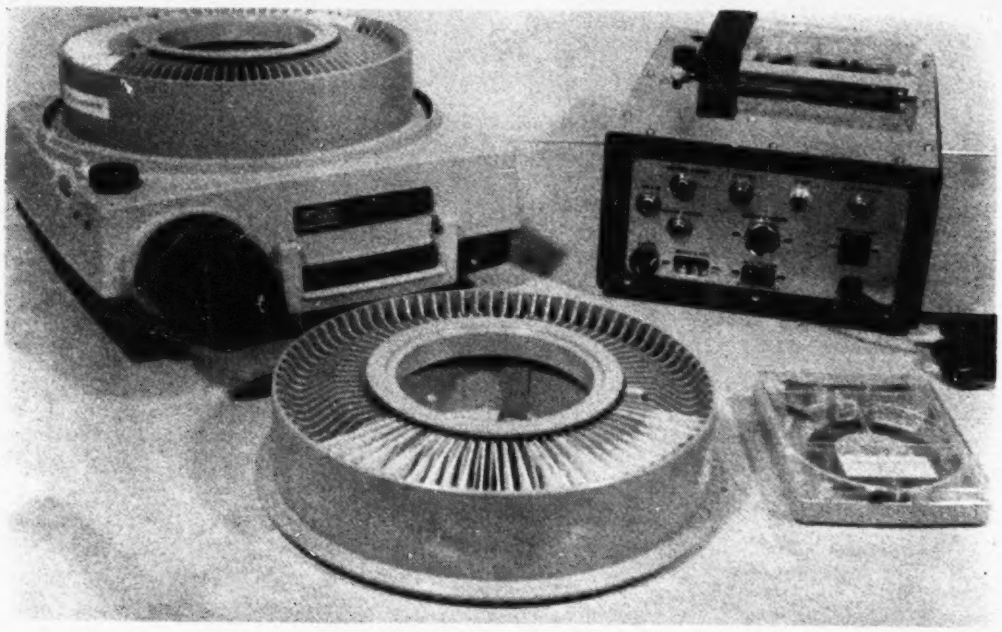

Fig. 2.--The Audion Tape Recorder and Carousel Slide Projector.

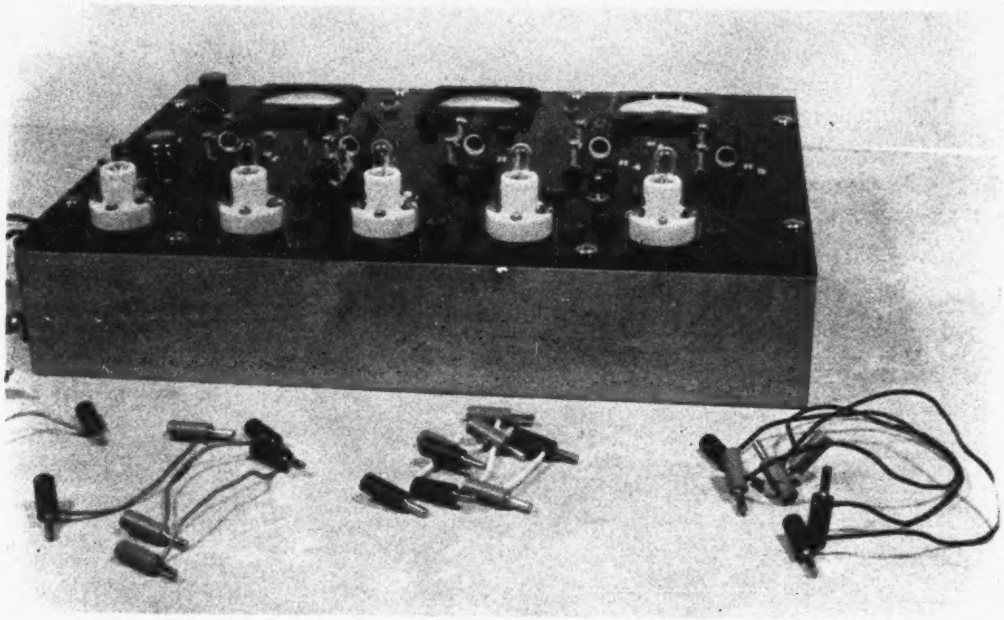

Fig. 3.--Laboratory Apparatus

Instructor's Guide and Student Workbook Development

The instructor's guide is designed to prepare the teacher for use of the system. Objectives are listed, and media are named and described. Safety practices are also outlined and emphasized. A step-by-step procedure for using this self-instructional system is included. The guide is reproduced in Appendix E. The guide has been designed to cover six projected lessons in basic electricity. Only Lessons I and II have been completed. They constitute the substance of this report. Personnel associated with the research project at Washington State University are at work completing the remaining four lessons.

The student workbook is a vital part of this system. The student uses it constantly throughout the tape-slide presentation. It has been organized so that the student is given the necessary instruction and information to progress unassisted through the system. In the first section pictures and directions assist the student to organize the media for the first lesson, "Equipment Operation." From this point on, the workbook provides work sheets on which the student records responses. The work sheets for each lesson are printed on a different color of paper. This facilitates student use of the media.

A lesson evaluation form is provided after each set of work sheets. The student is asked to fill out this form immediately after completing the lesson. These data will contribute to system revision. The student workbook is present in Appendix F.

Pretest and Posttest Development

The success of a system approach is measured in terms of student capability to perform at predetermined levels of competence. Evaluation instruments were developed and employed to determine student competencies in the area of basic electricity both before and after use of the system. These pre and posttests were developed from the established behavioral objectives for Lessons I and II.

Several questions covering advanced materials from Lesson III were included. The reason for this was to determine if learning was taking place as a result of this testing. Gain scores for these questions indicates learning that cannot be directly attributed to the instruction.

Parallel test forms were constructed in an attempt to reduce memory carry over from pre to posttest. The test questions were developed and submitted to a jury of experts who evaluated them for content validity. The final test form was then prepared. Copies of these tests, the instructions for administering them, answer sheets, and the list of jury members who evaluated them have been included in Appendix G. An information sheet is also included which shows the correspondence between the two parallel forms and identifies each test question with the lesson which covers that concept.

Performance Test Development

The students' dexterity and skill in handling the laboratory equipment was judged to be a factor which would affect the time each student used to complete work required by the system. As a result, a performance test was developed which utilized a circuit board and conductors similar to the equipment provided with the laboratory apparatus. To administer the test, the student was first given oral instructions on the purpose and procedures involved with the test. This test consisted of the construction of three circuits on the board. (See Fig. 4.) First, the student was given a sample problem to work through with the assistance of the tester. Sketches of the completed circuits were used by the student as a guide. Times required to construct each circuit and the number of errors made on each were recorded. The total time consumed by each student and the number of errors he made constituted his performance test score.

Validity of the pre, post, and performance tests is based upon a content or "factor analysis" approach. As Lyman suggests:

> We may check an achievement test to see whether each item covers an important bit of knowledge or involves an important skill related to a particular training program. Or we may start off with a detailed outline of our training program and see how thoroughly the test covers its important points.[13]

Instructions, data sheet, and sketches of circuits for the performance test are presented in Appendix G.

The Experimental Population

The sample used for this study was drawn from students in Anatone and Pullman, Washington. This sample is composed of 30 boys and girls, ranging from third-graders to seniors in high school. These students were selected by teachers from volunteers in the various schools. Table 2 shows the distribution of the sample by grade while Table 3 shows the distribution of the sample between the two sexes.

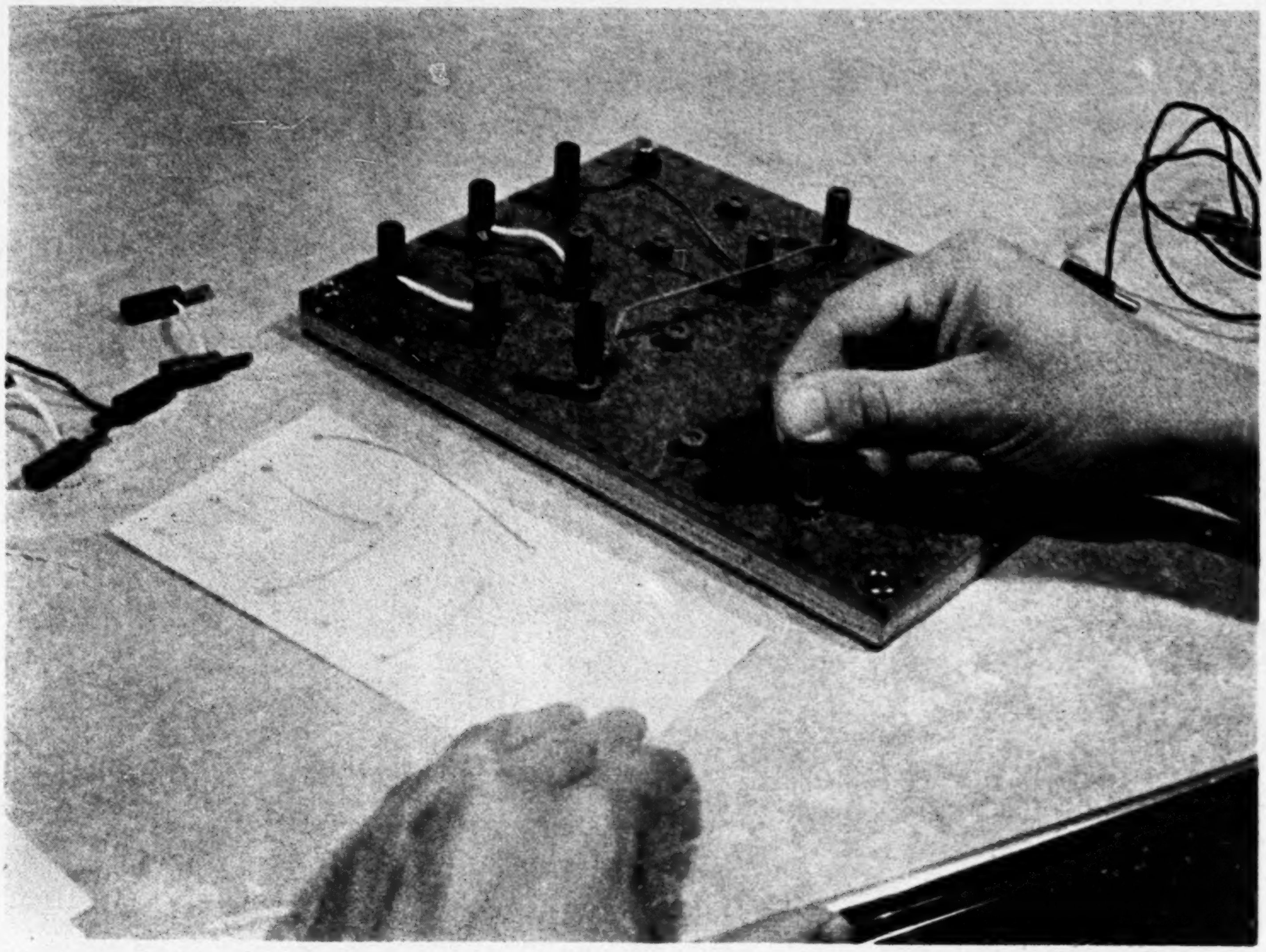

Fig. 4.--Performance Test

TABLE 2

SAMPLE DISTRIBUTION BY GRADE LEVEL

Grade Level	Number
3	3
4	1
5	8
6	2
7	1
8	3
9	3
10	3
11	2
12	4
Total	30

TABLE 3

SAMPLE DISTRIBUTION BETWEEN SEXES

Sex	Number
Boys	19
Girls	11
Total	30

Two students were unable to complete the instruction, and two completed all instruction but were unable to take the posttest. The data collected for these four cases have been retained and will be included in the analysis where pertinent.

It was assumed that the general ability of the student would affect their success with the instruction. Therefore, Differential Aptitude Test (DAT) scores were obtained for all high school students. Those DAT scores were interpreted as percentile rank scores. Intelligence Quotients were also obtained from the files for elementary students involved in the study. These IQ scores were from the Otis Quick-Scoring Mental Ability Tests, forms A and B; the California Test of Mental Maturity, 1963, Revision Level 1; and the Henman-Nelson Test of Mental Ability for Grades 3-6.

It was realized that scores from the above tests could not be compared directly with any degree of accuracy; therefore, they were mathematically equated and converted to percentile ranks by means of the "Conversion Table for Derived Scores" found in the Appendix of Lyman's book, Test Scores and What They Mean.[14]

A rank distribution of these adjusted percentile scores is shown in Table 4. For purposes of analysis, this distribution has been divided into three groups: high, average, and low.

Procedures

Knowledge and performance tests, pretests, were administered to all members of the sample by the researcher prior to any explanation of the instructional system. It was emphasized to the student that results of these tests would not affect their grades in class.

The teachers of the Anatone and Pullman schools then administered the system as directed by the instructor's guide which outlines the specific steps for using the self-instructional media.

TABLE 4

RANK DISTRIBUTION OF PERCENTILE SCORES

Percentile Score	Grouping
99	HIGH
99	
97	
97	
95	
94	
93	
93	
92	
90	
90	
88	AVERAGE
86	
86	
85	
85	
85	
84	
80	
78	
75	
75	
70	LOW
65	
65	
45	
40	
30	
25	
20	

The console was placed in a small study room ajoining the Industrial Arts shop at Anatone and used in the back of the classroom at Pullman. Headphones were used so that class activities did not distract the participating student.

Only one student was permitted to work at the console at a time. Each was scheduled for a flexible block of time so that he could progress at his own speed. No student worked for more than an hour at any one time on the lessons. Most students completed the instruction in five or six sessions. In some cases two sessions were scheduled during the same day, one before and one after lunch.

When the student completed the two lessons he was given the posttest by the teacher. This posttest and the student's workbook were put in a large envelope which contained his pretest and performance data. Also included was a record of the amount of time the student used on the lessons, his evaluation of each lesson, and the pretest/posttest time. This time between pretest and posttest varied among members of the sample because of the intervening school functions and individual student activity.

Close contact between the researcher and assisting teachers was maintained throughout this study. Particular emphasis was placed on adherence to the directions for administration of the system.

The workbooks, tests, and slide-tape sequences used for this study are available through ERIC Vocational Education Center, Ohio State University, Columbus, Ohio. The prototype student operated console can be seen at Washington State University, Department of Education, Pullman, Washington.

References, Chapter III

[1] U.S. Office of Education Grant for Vocational-Technical Education Research and Development Project (ERD-257-65), Gordon McCloskey (Director), Washington State University, Pullman, Washington, 1966.

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[3] Dale L. Nish, "The Poly-sensory System: An Experiment to Determine Its Efficiency in Teaching Skills and Concepts Involved in the Use of Polystyrene Plastics," Ed.D. dissertation, Washington State University, 1967.

[4] Harold A. Sergeant, "The Development and Testing of an Experimental Self-Instructional System for Teaching Arc Welding Processes," Ed.D. dissertation (in progress), Washington State University, 1967.

[5] Identification of Task and Knowledge Clusters Associated with Performance of Major Types of Building Trades Work, Report prepared under the direction of Dr. William A. Bakamis for the Vocational-Technical Education Research and Development Project ERD-257-65, Washington State University, 1967. (Mimeographed.)

[6] Major Task and Knowledge Clusters Involved in Performance of Electronic Technicians' Work, Report prepared by Dr. Boyd Mills for the Vocational-Technical Education Research and Development Project ERD-257-65, Washington State University, 1967. (Mimeographed.)

[7] Fred P. Barnes, Research for the Practitioner in Education, Washington, D.C.: Department of Elementary School Principals, National Education Association, 1964, pp.61-64.

[8] Howard B. Lyman, Test Scores and What They Mean, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963, pp. 207-212.

[9] Robert F. Mager, Preparing Instructional Objectives. Palo Alto, California: Fearon Publishers, 1962, p. 3.

[10] Wilbur J. Farr, "Educational Needs of Urban Residents Concerning the Use of Electricity in the Home" (Unpublished Ph.D. dissertation, University of Missouri, 1958), Dissertation Abstracts, LIIX, 5238.

[11] William H. Allen, "Media Stimulus and Types of Learning," Audiovisual Instruction, XII (January, 1967), 27-31.

[12] Jerrold E. Kemp, Planning and Producing Audiovisual Materials, San Francisco, California: Chandler Publishing Company, 1963, pp. 16-31.

[13] Lyman, Test Scores and What They Mean, p. 27.

[14] Lyman, Test Scores and What They Mean, pp. 207-212.

Chapter IV

FINDINGS AND ANALYSIS OF DATA

This chapter analyzes and interprets results of the experiment as they relate to the specific objectives of this study. These objectives are:

1. To develop the experimental polysensory self-instructional system.
2. To measure the extent to which students acquire defined levels of electrical occupational competencies by use of this system.
3. To determine the various amounts of instructor assistance needed for acquisition of the defined levels of competencies.
4. To measure how much instruction time is needed to acquire defined levels of competency by use of the system.
5. To obtain indications of ways the system can be improved.

Analysis Procedure

To facilitate analysis, the data were coded, entered on punch cards, and processed by an IBM 360-Model 67 computer. Contingency tables were developed which show the distribution of variables. Each of the 32 variables coded are compared individually with every other variable.

Referring to contingency tables, Ferguson states: "With such tables, chi square provides an appropriate test of independence."[1] This measure is widely accepted and levels of significance are readily available. For these reasons, chi square, the degree of association between the two variables, and the degrees of freedom for each table were calculated. The degree of association between two variables is supplied by the contingency coefficient (C). The phi coefficient was calculated instead of C for all 2 x 2 tables.[2]

Because of the small N involved in the sample, Yates's correction for contingency was applied in all cases in which the data constituted a 2 x 2 table and/or the expected frequency was less than 10.[3] This gave a conservative value for chi square.

Fisher's exact test of significance was calculated for all 2 x 2 tables. This test is particularly appropriate where the expected cell frequencies are small. The only major objection to its use is the laborious calculations required.[4] The computer has eliminated this disadvantage in this case.

Other measures of association with regard to contingency tables have been discussed in the literature. One of these, Goodman and Kruskal's tau,[5] is described by Blalock as a measure with an intuitive meaning which enables the researcher to "interpret values intermediate between zero and one."[6] He suggests that this measure is superior to those based on chi square, particularly when a small sample is involved.

Costner discusses both Goodman and Kruskal's tau and lambda. He states: "These two measures have been specifically designed as proportional-reduction-in-error measures of association between two nominal variables."[7] Lambda measurements impose no restrictions on the number of classes and requires no unrealistic assumptions about the distribution of the variables. This measure is directly interpretable and for data such as obtained by this study, "makes better sense than most of the others."[8] Prompted by these comments the researcher has calculated lambda and tau values for each table.

The sum, mean, standard deviation, and range for each of 26 raw data variables was also calculated. These values will be used to describe the parameters of the sample.

Analysis of Data Relevant to Objective 1

The development of the polysensory self-instructional system has been reported in detail in Chapter III. The materials themselves and a step-by-step report of their development has been included because that may be beneficial to others attempting instructional systems development.

Analysis of Data Relevant to Objective 2

To ascertain the degree to which the system enables pupils to acquire the defined levels of electrical occupational competencies; gain scores and posttests scores for Lessons I and II have been analyzed. Table 5 describes the gain for Lessons I and II in terms of sums, means, standard deviations, and ranges.

Interpretation of gain scores will provide the reader with a better understanding of the extent to which the system functions as a learning device. When mean gain scores are compared with the maximum mean gain for each lesson, a per cent of gain can be calculated. To determine the maximum mean gain for

TABLE 5

SUMS, MEAN, STANDARD DEVIATION AND RANGE OF GAIN SCORES FOR LESSONS I AND II

Lesson	Sums	Mean	Standard Deviation	Range
I	59.0	1.97	2.482	6
II	60.0	2.00	2.732	8

Lessons I and II, the respective mean pretest scores have been subtracted from each lesson's total possible score. In essence, this recognizes the average knowledge the student possessed before exposure to the system and expresses the maximum gain in terms of the remaining knowledge to be acquired. Table 6 presents this information.

TABLE 6

PERCENTAGE OF GAIN FOR LESSONS I AND II

Lesson	Mean Pretest	Possible Score	Maximum Gain	Students Mean Gain	% Gain
I	2.07	6	3.93	1.97	50.1
II	2.60	8	5.40	2.00	37.0

The data show a total mean gain for lesson I and II of 3.97. This represents 43.6 percent of the possible gain for the two lessons. In other words, the students learned, on the average, 43.6 percent of the new material presented to them by the system.

Analysis of posttest scores with regard to possible final scores also gives an indication of the student's achievement. Table 7 shows mean achievement levels for Lessons I and II based on posttest scores. Note that the average achievement for Lessons I and II was at the 60.1 percent level.

TABLE 7

ACHIEVEMENT LEVELS FOR LESSONS I AND II AS DETERMINED BY POSTTEST SCORES

Lesson	Posttest Mean	Maximum Score	Per Cent of Achievement
I	3.83	6	63.8
II	4.50	8	56.3

The previous data has represented the average results for the entire sample. To appraise the effect of this system with regard to levels of electrical occupational competencies acquired by particular types or groups of individuals, gain and achievement levels must be analyzed in light of a number of variables. The variables to be considered are:

1. grade level
2. previous knowledge of electricity
3. capabilities to perform laboratory work
4. general mental ability
5. time elapsed between pre and post measures of knowledge
6. sex differentiation

Grade Level

Table 8 correlates grade level with gain scores from Lessons I and II.

TABLE 8

FREQUENCY DISTRIBUTION SHOWING GRADE LEVEL CORRELATED WITH GAIN FOR LESSONS I AND II

Grade Level	Gain--Lesson I			Gain--Lesson II		
	No Gain	Low 1-2	High 3 and over	No Gain	Low 1-2	High 3 and over
Elementary 3-6	0	4	6	3	1	6
Jr. High 7-9	1	1	5	0	3	4
Sr. High 10-12	1	5	3	1	7	1

The conditions for significance at the .05 level were not met by the chi square test, therefore generalizations cannot be made with accuracy concerning relationships between grade level and gain in electrical knowledge attributed to the system.

Upon examination of the table, one can note that more elementary students experienced high gain scores than did Jr. or Sr. High students. In fact, 60 percent of the third through sixth graders had a gain score of 3 or better on both lessons. These elementary students with "high gain" scores comprised 23 percent of the sample as compared to 17 percent contributed by Jr. High and 8 percent by Sr. High school students. It would seem, then, that elementary students gained more knowledge from the system than did other grade levels.

Previous Knowledge

This distribution of gain scores can be partly explained by examination of pretest scores with regard to grade level. It may be assumed that younger students will possess less knowledge of electricity and therefore have an opportunity to increase their knowledge by a greater measure, resulting in larger gain scores. This assumption was found valid when the relationship between grade level and pretest scores was examined. These results are presented in Table 9.

TABLE 9

FREQUENCY DISTRIBUTION SHOWING GRADE LEVEL CORRELATED WITH PRETEST SCORES FOR LESSONS I AND II

	Pretest--Lesson I		Pretest--Lesson II	
	Low 0-3	High 4-6	Low 0-4	High 5-8
Elementary 3-6	14	0	14	0
Jr. High 7-9	6	1	7	0
Sr. High 10-12	5	4	4	5

It can be seen that all elementary students in the sample scored low on the pretest. In contrast only 50 percent of the senior high students in the sample scored in the low category. A significant correlation between pretest scores and gain for Lesson I was established at the .05 level.

General Mental Ability

Further analysis of the variables revealed very little correlation between general mental ability and gain scores. Table 10 presents the data for this relationship.

TABLE 10

FREQUENCY DISTRIBUTION SHOWING IQ PERCENTILE CORRELATED WITH GAIN FOR LESSONS I AND II

IQ Percentile	Gain--Lesson I			Gain--Lesson II		
	No Gain	Low 1-2	High 3 and Over	No Gain	Low 1-2	High 3 and Over
Low 20-70	1	3	4	1	5	2
Average 75-88	0	4	7	1	3	7
High 90-99	1	3	3	2	3	2

The contingency coefficient, C, equals 0.113, which is not significant.[9] This suggests that low, average, and high ability students learn equally well from the system.

Laboratory Capabilities

The capability of the student to perform the laboratory operations was hypothesized to be closely associated with gain in electrical knowledge. Performance scores including total test time and number of test errors were correlated with gain scores. The relationship between test errors and gain scores was quite low. In addition, the relationship between performance test time and gain for Lesson I, which involved no laboratory exercises, was also insignificant. The distribution between performance test time and gain for Lesson II, however, was significant at the .05 level. These data are presented in Table II.

TABLE 11

FREQUENCY DISTRIBUTION SHOWING PERFORMANCE TEST TIME CORRELATED WITH GAIN FOR LESSONS I AND II

Performance Time	Gain--Lesson I			Gain--Lesson II		
	No Gain	Low 1-2	High 3 and Over	No Gain	Low 1-2	High 3 and Over
Fast 100-133	1	3	5	0	7	2
Average 150-195	1	5	3	1	4	4
Slow 210-405	0	2	6	3	0	5

Pre/Post Test Time

The time that elapsed between the pretest and posttest was examined as an intervening factor which may effect the amount of gain. An extremely low degree of association, 0.086, was found to exist between these variables. Thus, differences in pre to posttest time has been disregarded as a valid variable of the study.

Sex

The researcher also compared the gain scores of girls with those of boys. Here again, no significant difference was obtained. The distribution of gain scores with regard to sex has been included in Table 12.

TABLE 12

FREQUENCY DISTRIBUTION OF PERCENTAGES SHOWING SEX CORRELATED WITH GAIN FOR LESSONS I AND II

Sex	Gain--Lesson I			Gain--Lesson II			Average Gain		
	No Gain	Low 1-2	High 3 and Over	No Gain	Low 1-2	High 3 and Over	No Gain	Low 1-2	High 3 and Over
Male	11.78	47.04	41.18	17.65	52.94	29.41	14.71	50.00	35.29
Female	0	22.22	77.78	11.11	22.22	66.67	5.56	22.22	72.22

The number of students in each gain category has been converted into a percent based on the total number of students of the respective sex. These percentages represent the distribution of the sample in Lessons I and II and the average distribution when data on both lessons are combined.

Analysis of Data Relevant to Objective 3

The system was designed to function as a self-instruction device for learning. To determine the degree to which this objective was met, data were collected concerning the number of times instructor assistance was requested and the length of time used for this assistance. This information is shown in Table 13. The sums, means, standard deviations, and ranges of these data are shown for the Equipment Operation lesson and Lessons I and II.

TABLE 13

SUMS, MEANS, STANDARD DEVIATIONS, AND RANGES OF THE NUMBER OF INSTRUCTOR ASSISTS AND THE AMOUNT OF ASSISTANCE TIME REQUESTED FOR LESSONS: EQUIPMENT OPERATION, I AND II

	Lesson	Sums	Means	Standard Deviations	Ranges
No. of Assists	Equip. op.	25	0.83	1.354	4
	I	6	0.20	0.516	2
	II	4	0.13	0.447	2
Time (min.)	Equip. op.	31	1.03	1.703	5
	I	8	0.27	0.730	3
	II	4	0.13	0.447	2

Inspection of Table 13 reveals that the greatest number of assist requests occurred during the Equipment Operation Lesson. In addition, the greatest amount of assistance time was also used during this lesson. Fewer assists and shorter time was recorded for Lesson I and need for assistance continued to decrease in Lesson II. No one asked for more than four assists during any lesson and the average number of assists was less than one.

The pattern established by the data presented in Table 13 indicate a condition approaching self-instruction as the student became familiar with the media. This quality of the system seems to be verified when it is noted that an average of a mere 0.13 minutes (or approximately 8 seconds) of instructor assistance was needed per student for the final lesson, Lesson II.

The number of instructor assists was compared with grade level. These data are presented in Table 14.

TABLE 14

FREQUENCY DISTRIBUTION SHOWING GRADE LEVEL CORRELATED WITH NUMBER OF TIMES INSTRUCTIONAL ASSISTANCE WAS REQUESTED DURING LESSONS: EQUIPMENT OPERATION, I AND II

Grade	Instructional Assistance					
	Equipment Operation		Lesson I		Lesson II	
	No Help	I or More Times	No Help	I or More Times	No Help	I or More Times
Elementary 3-6	7	7	11	2	10	2
Jr. High 7-9	3	4	6	1	6	1
Sr. High 10-12	6	3	7	2	9	0

The results failed to provide a significant correlation and the degree of association between variables was less than 0.100. This suggests that the system functioned independently for a variety of age levels.

Other variables have been analyzed to determine their influence on the functioning of the system. These variables include:

1. general mental ability
2. previous knowledge of electricity
3. final level of achievement
4. gain
5. sex differentiation

The degree of association between the amount of assistance requested and each of these variables was small. A significant correlation could not be established. This suggests that the functioning of the system may be independent of these variables.

Analysis of Data Relevant to Objective 4

The students' progress through the system was observed and the time spent on each lesson was recorded. These data have been analyzed in an attempt to determine the instruction time required to acquire defined levels of competence. Table 15 presents a description of the sample with regard to this data. As can be calculated, the total mean time required to go through all three lessons was 200.6 minutes or approximately 3 1/3 hours.

A varying amount of instruction time was used as is indicated by the range values. Factors studied which might influence this diversity were:

TABLE 15

SUMS, MEAN, STANDARD DEVIATION AND RANGE OF INSTRUCTION TIME FOR LESSONS: EQUIPMENT OPERATION, I AND II

Lesson	Sums	Means	Standard Deviation	Range
Equipment Operation	1165	38.83	41.658	60
I	1400	46.67	49.579	85
II	3453	115.10	125.411	180

1. grade level
2. previous knowledge of electricity
3. general mental ability
4. capability to perform laboratory work
5. gain
6. final level of achievement
7. sex differentiation

The chi square test of significance revealed only one of these variables, previous knowledge of electricity, had a significant relationship with the amount of instruction time. This correlation was significant at the .01 level when pretest results on Lesson II were compared with instruction time used on Lesson II. This may indicate that the system is sensitive to individual differences in student knowledge and permits each individual to progress at his own speed.

The frequency distribution for this relationship is shown in Table 16. The Fisher's exact probability test indicates that the probability of this distribution occurring by chance is 0.02.

TABLE 16

FREQUENCY DISTRIBUTION SHOWING THE CORRELATION BETWEEN PRETEST SCORES AND INSTRUCTION TIME FOR LESSONS I AND II

Lesson	Pretest Score	Instruction time	
		Fast	Slow
I	Low	11	13
	High	3	2
II	Low	9	14
	High	5	0

Analysis of Data Relevant to Objective 5

Research with linear programmed learning materials indicates that retention is greatest when the program produces a low student error rate. Some research suggests that an error rate of 4 percent or less is desirable.[10] The errors were compiled from the student workbooks for each lesson of this system. A description of these errors is presented in Table 17.

To calculate the percent of errors or error rate for each lesson the number of errors has been divided by the respective number of responses for the lesson. Table 18 shows the results of this computation. The average error rate for all lessons was 16.4 percent.

TABLE 17

SUMS, MEAN, STANDARD DEVIATION AND RANGE OF ERRORS ON LESSONS: EQUIPMENT OPERATION, I AND II

Lesson	Sums	Means	Standard Deviation	Range
Equipment Operation	67	2.23	2.868	6
I	131	4.37	5.392	11
II	158	5.27	6.484	13

TABLE 18

STANDARD ERROR RATE ON LESSONS: EQUIPMENT OPERATION, I AND II

Lesson	Responses	Mean Errors	Error Rate (%)
Equipment Operation	12	2.23	18.6
I	22	4.37	19.9
II	49	5.27	10.7

Indications for revision of the system have been obtained from a variety of data. The errors made by each student were recorded with regard to the lesson and response number. This information indentifies the responses which cause the students the most difficulty. A careful analysis and rewording of response requests can be undertaken, resulting in an anticipated reduction in the error rate.

At the completion of each lesson the students were directed to evaluate the instruction. The students were requested to check rate the media and lesson content, and explanatory comments were encouraged. The results of these evaluations have been compiled and should be considered when revision of the system is undertaken.

An encouraging note is that a majority of the students indicated they liked the lessons. The frequency distribution concerning this response is shown in Table 19.

TABLE 19

FREQUENCY DISTRIBUTION SHOWING STUDENT REACTION TO THE SYSTEM

Response	Lessons		
	Equipment Operation	I	II
I liked the tape-slide lesson	28	20	24
I did not like the tape-slide lesson	2	5	2

In further analysis of this data, characterists of the students have been studied with regard to the evaluation comments they made. The intent of this analysis was to identify factors which might have prompted the student to respond as he did. Student characteristics considered were:

1. grade level
2. general mental ability
3. previous knowledge of electricity
4. sex differentiation
5. gain
6. final level of achievement
7. response error rate

Extensive analysis produced very little association between these variables. For this reason no further discussion of these relationships will be presented.

Evaluation of the system was also obtained from a jury of twenty high school electronics teachers, who were participating in an Industrial Arts NDEA Institute at Washington State University. Participants were selected from a list of 317 applicants from the twenty-seven states west of the Mississippi River.

Each jury member examined the teacher's guide, the student workbook, and representative portions of Lessons I and II. After this exposure they were asked to fill out evaluation forms identical to those used by the students. Suggestions from the group were encouraged and recorded on tape. Later content from these tapped discussions and comments submitted with the evaluation forms were organized and listed on data sheets. Included with these data sheets is a directory of the jury members, and their evaluation of the media. A summary of the jury's reaction to the system is presented in Table 20.

TABLE 20

FREQUENCY DISTRIBUTION SHOWING JURY'S REACTION TO THE SYSTEM

Response	Lesson I	Lesson II
I liked the tape-slide lesson	6	16
I did not like the tape-slide lesson	5	0

Examination of this table shows that the jury members were almost equally divided in their impression of the first lesson. The second lesson, however, had their unanimous approval.

School personnel involved in the field test of the system were also asked to evaluate the lessons with regard to content and administrative characteristics. These evaluations are presented in Table 21.

Additional information was obtained from interviews and discussions with the school personnel.

1. Do you think the students enjoyed learning with the system and why?
2. Did you experience any trouble administering the system?
3. Do you have any suggestions for improvement of the system?

TABLE 21

SCHOOL PERSONNEL EVALUATION OF THE SYSTEM

Criteria	
1. Interest	Low for older students who had already covered material in previous courses.
2. Supervision time	Very little needed.
3. Rate--Level Comprehended	Best suited for Jr. High students. Third grade students were able to use the system with more instructor assistance.
4. Utility	Components of system were complete.
5. Format	Need branching design to allow for individual differences.
6. Content.	Good--also need take-home project.
7. Psychological and Educational Value	Very necessary in school curriculum.

References, Chapter IV

[1] George A. Ferguson, *Statistical Analysis in Psychology and Education* (2d ed. rev.; New York: McGraw-Hill Book Co., 1966), p. 201.

[2] Sidney Siegel, *Nonparametric Statistics for the Behavioral Sciences* (New York: McGraw-Hill Book Co., 1956), pp. 196-202.

[3] Ferguson, *Statistical Analysis in Psychology*, p. 207.

[4] *Ibid.*, p. 208.

[5] L.A. Goodman and W.H. Kruskal, "Measures of Association for Cross Classification," *Journal of the American Statistical Association*, IL (December, 1954), 732-764.

[6] Hubert M. Blalock, Jr., *Social Statistics* (New York: McGraw-Hill Book Co., 1960), p. 232.

[7] Herbert L. Costner, "Criteria for Measures of Association," *American Sociological Review*, XXX (June, 1965), 351.

[8] Linton C. Freeman, *Elementary Applied Statistics: for Students in Behavioral Sciences* (New York: John Wiley and Sons, 1965), p. 71.

[9] Ferfuson, P. 236.

[10] James G. Holland and Douglas Porter, "The Influence of Repetition of Incorrect Answered Items in a Teaching-Machine Program," *Journal of the Experimental Analysis of Behavior*, IV (February, 1961), 305-307.

Chapter V

SUMMARY AND RECOMMENDATIONS

Summary

Findings relating to the five objectives of this study follow.

Objective 1: To develop an experimental polysensory self-instructional system.

The mode of development has been analyzed and reported in Chapter III. Extensive detail is included in the hope that the effort expended on this phase of the study might assist others in further systems development. Particular emphasis has been placed upon the need for careful planning, which includes: identification of behavioral objectives; determining learning experiences; sequencing these experiences; and then selecting media to facilitate the activity associated with each experience.

A description of components and recommended procedures for the development of educational media has been included. Even though the format and media will vary from system to system, awareness of basic audio-visual methodology is necessary for efficient, effective system development.

Objective 2: To measure the extent to which defined electrical occupational competencies are developed by use of this system.

The students experienced an average mean gain in knowledge of 3.97 for Lesson I and II. This represents 43.6 percent of the possible gain for the two lessons. Analysis of posttest scores indicated that the average achievement for the two lessons occured at the 60.1 percent level.

There was little correlation between general mental ability and gain, which suggests that students with varying intellectual capabilities performed equally well. A significant correlation was established between the student's ability to manipulate laboratory apparatus as measured by the performance test, and the gain for Lesson II, which involved this type of activity.

Objective 3: To determine the various amounts of instructor assistance needed for acquisition of the defined competencies.

It was found that the system functioned independently of instructor assistance a major part of the time. Some students required some assistance at the beginning but as the student became familiar with this mode of study, the amount of assistance requested diminished to an average of 8 seconds per student on Lesson II.

There was no significant correlation between the amount of assistance requested and grade level. This indicates that students in grades 3 through 12 used the system effectively as a self-instructional device. The maximum number of requests for assistance was four and the average for Lesson I and II was less than one.

Objective 4: To measure how much instruction time is needed to acquire defined levels of competence by use of the system.

The total mean time required to complete all three lessons was 200.6 minutes or approximately 3 1/3 hours. Previous knowledge of electricity had a significant effect on completion time. The correlation, as tested by chi square, was significant at the .01 level. These findings may indicate the system functioned with respect to individual student differences.

Objective 5: To obtain indications of ways the system can be improved.

The average error rate for all lessons was 16.4 percent. This is considerably above the suggested rate of 4 percent. A revision of response items is indicated by the error frequency record for each. Additional information obtained from the evaluation jury, the students, and the school personnel involved should prove helpful for system revision. Eighty-seven percent of the evaluations of the system indicated approval of the lessons.

At the outset, it was indicated that the purpose of this study was to develop a polysensory, self-instructional system and test its effectiveness. After analysis of the data it seems apparent that the experimental system does promote learning. Statistical evidence from this study supports the concept that some types of instruction via polysensory self-instruction systems can be exceptionally effective. Basic electrical competencies were gained by students who differed greatly in age and ability.

Motivation associated with this mode of instruction seemed high, especially where theoretical information was applied to laboratory experiences. Students indicated that they could understand basic concepts with relative ease and that they enjoyed learning this way.

The self-instructional characteristics of the system were quite apparent. Very little instructor time was requested by individual students. After becoming familiar with this mode of instruction they requested less than 17 seconds of instructor assistance per pupil, per lesson. This is an advantage which should be considered when evaluating the system.

The variance in the amount of time taken by students to complete the instruction suggests that the system is sensitive to individual differences with regard to pacing. Critics felt more consideration should be given to the individual's capabilities at the entry point to the system. Branching, preentry evaluation, or other modifications of the media format would allow students with previous knowledge of electricity to begin instruction with new and challenging material.

Improvement of the system is anticipated with revision. Sufficient data has been collected by this study to guide valid revision. Comments by juries of experts, school officials, and students involved in the instruction, in addition to statistical results on student performance, have identified weak points of the system. Concise records of student progress by means of this instruction will be helpful in making decisions concerning sequencing, emphasis, and organization of system content.

Recommendations

It is recommended that the format of this study be revised and replicated on a larger scale. The author has refrained from generalizing with respect to either larger populations or other learning situations. Such generalizations may be appropriate, however, after system revision and replication. The inclusion of college students in the sample seems feasible if the content of the lessons is adjusted to correspond to their ability level.

Instruction of this type should also be used and tested with students in larger school systems. Its use in this setting may serve as a useful supplement to the existing instructional program.

It is also suggested that use of the system in small group learning situations be explored. Interaction between the students may prove a valuable component of the system.

Future systems research should include use of new media and devices currently in developmental stages. Such media continue to become available. For example, consideration should be given to innovations such as the Audiscan,[1] which is currently being tested at Washington State University. This device offers advantages such as compact construction, increased portability, and simplicity of operation.

In accord with suggestions by Guetzhow, Kelley, and McKeachie[2] it is recommended that similar experiments in other subject-matter fields be conducted. The extent to which such instruction can enable pupils to acquire skills as well as knowledges should be investigated.

It is recognized that a Hawthorne effect did exist during experimentation with this system. The degree to which this effect motivated students was not investigated as part of this study. Future reserach is needed to determine the extent to which use of the systems approach motivates the student and the degree to which this motivation is sustained over prolonged periods of instruction.

Footnote References--Chapter V

[1] Audiscan Inc., Advanced Audio-Visual Systems, 1414, 130th Ave., N.E., Bellevue, Washington, 98004.

[2] Harold Guetzhow, Lowel E. Kelley, and W. J. McKeachie, "An Experimental Comparison of Reaction, Discussion, and Tutorial Methods in College Teaching," Journal of Educational Psychology, VL (April, 1954), 193-207.

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Project No. OE7-0031 Final Report No. 19

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ABSTRACT

This project developed and tested a polysensory self-instructional system designed to help pupils acquire occupationally useful electrical knowledges and capabilities. The system is comprised of a teacher's guide, programmed instruction book, series of slide-tape sequences and a circuit board. Content includes forms of electrical energy, energy transmission and the nature of simple circuits.

Preliminary tests with 30 male and female pupils ranging from third to twelfth grade demonstrated that by use of the system for independent study, pupils do generally acquire predefined levels of capability. Amounts of time pupils use to achieve defined levels of capability vary. Variations are associated with differences in age and mental ability.